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Statement of Function:

This document describes the specific functional performance requirements for AutoSplit transmission system, which is based on the R747 transmission.

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Exhibit 25

PROPRIETARY NOTICE

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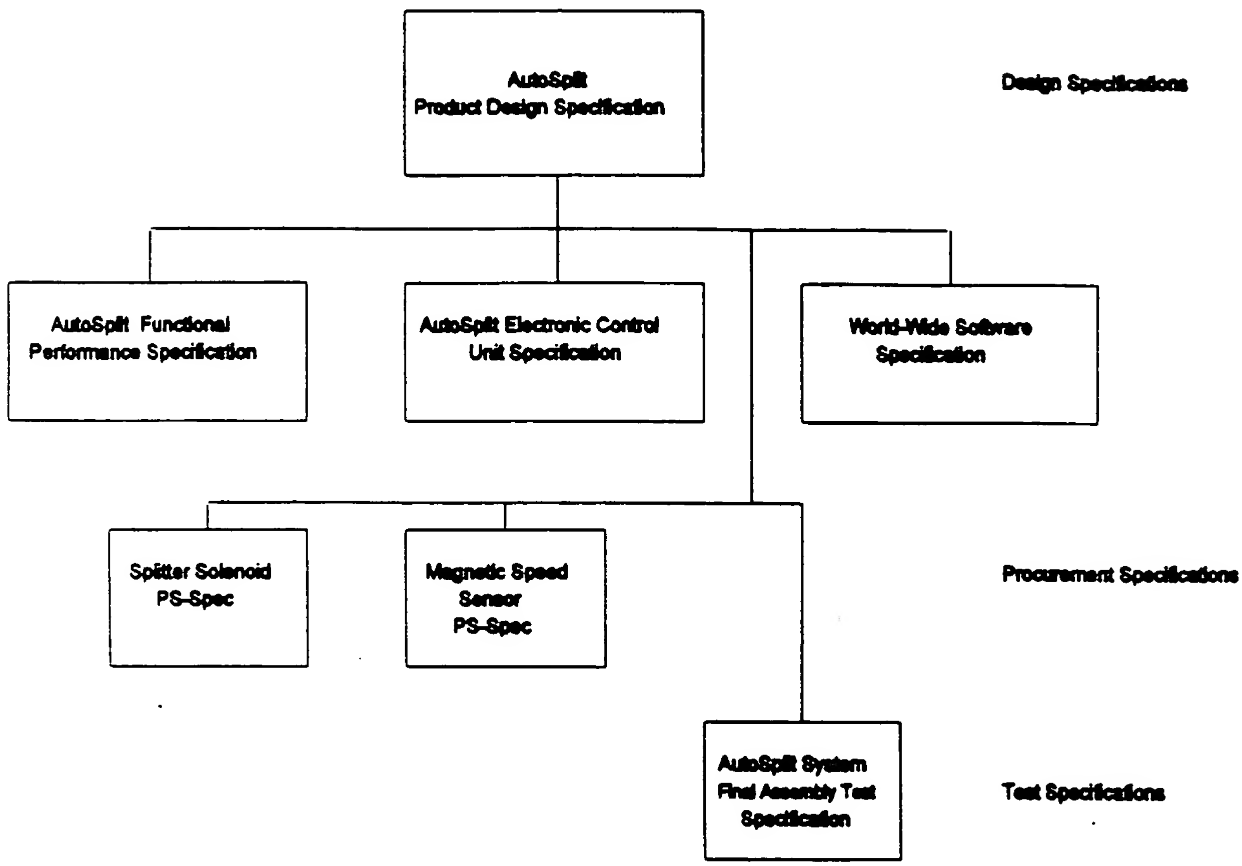
LINKED SPECIFICATION TREE

This diagram illustrates the hierarchy and linkage between specification which define the AutoSplit™ System.



REVISION LOG

DATE	Section	Changes Made

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1 INTRODUCTION

1.1 Purpose

The intent of this performance specification is to document the functionality, diagnostics, and error handling methods of AutoSplit™ algorithms. *Italicized* words seen throughout this document are configuration performance parameters which are programmable in EEPROM. **Bold** print, other than section headers, indicate a status input into the system.

1.2 Scope

This document describes the AutoSplit™ system level functional requirements. These requirements are defined using the intended electrical and mechanical constraints defined in specifications found in the Linked Specification Tree.

1.3 Acronyms and Abbreviations

ECU	Electronic Control Unit
EEPROM	Electronically Erasable Programmable Read Only Memory
CAN	Controller Area Network (also referenced as J1939)
ROM	Read Only Memory
RPM	Revolutions Per Minute
VBATT	Voltage, Battery (or Source)
VDC	Voltage, Direct Current
AutoSplit	The Eaton AutoSplit™ Transmission System
Super 10	Eaton Twin Countershaft, 10-speed transmission with range and splitter
R747	Next generation transmission family, of which the first model will be of the Super 10 configuration

2 LINKED SPECIFICATION LIST AND DOCUMENT CHANGE

2.1 Change Authority

All revisions or changes to this document will be maintained by the AutoSplit System Engineer. Revisions will be recorded in the revision log of this document.

2.2 Linked Specification List

- AutoSplit Product Design Specification
- Transmission Electronic Control Unit Specification
- Splitter Solenoid Valve Procurement Specification
- Magnetic Speed Sensor Specification
- AutoSplit System Final Assembly Test Specification

3 GENERAL DESIGN REQUIREMENTS

3.0.1 Brief Definition

The AutoSplit transmission system utilizes an R747 base transmission. All "splitter-only" shifts are fully automatic. In addition, all lever shifts feature automatic throttle manipulation and speed synchronization using J1939 engine control for easy lever shifting. This system results in clutch less shifting with no throttle manipulation after a manual clutch start. A simple dash display informs the driver of the "best" gear, available gears, and which gear the system is synchronizing for when the transmission is in neutral.

3.0.2 AutoSplit Inputs/Outputs

The block diagram in Figure 3.0.2-1 below describes the required inputs and outputs (I/O) of the AutoSplit system. For a more complete understanding of the AutoSplit hardware and interfaces, please refer to the "AutoSplit Product Design Specification."

AutoSplit Block Diagram

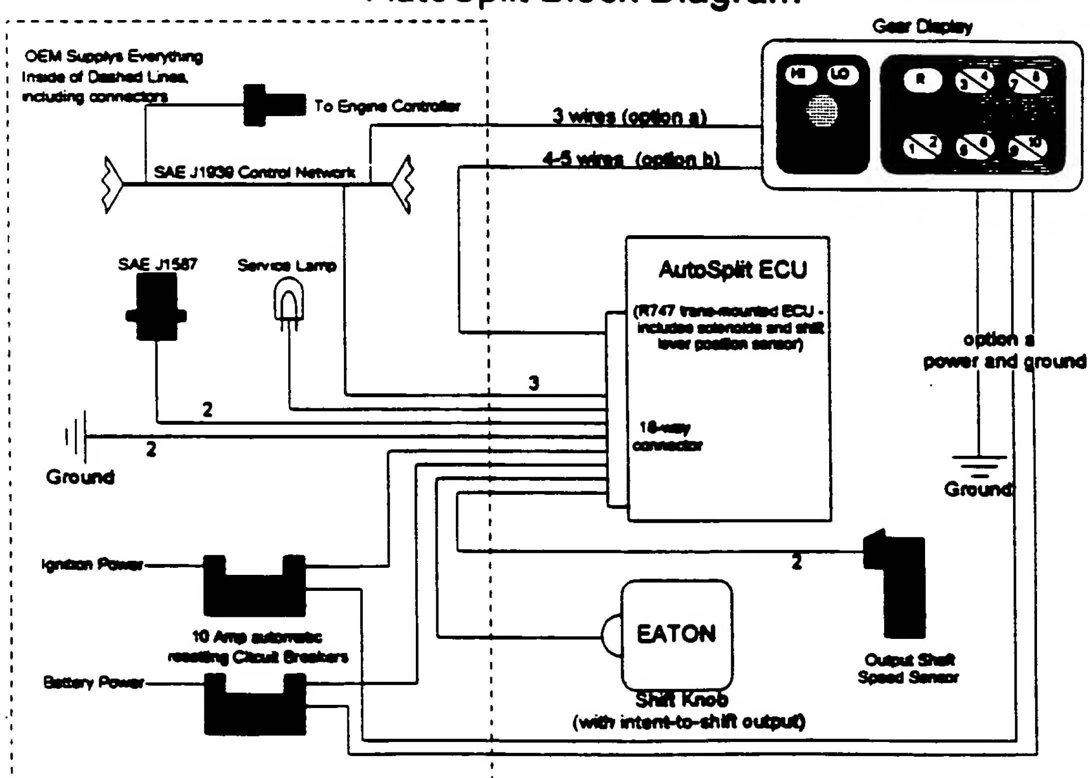

Figure 3.0.2-1 - AutoSplit Block Diagram

3.0.3 AutoSplit Sequence of Events

Normal AutoSplit operation consists of both driver-initiated (lever) shifts and system-initiated, automatic (splitter) shifts. The normal shift sequence for each of these shifts is as follows:

<u>Splitter-Only Shift</u>

1) The system detects the optimal time to shift based on load, **input_speed**, etc.
2) The system overrides cruise control, engine brakes, throttle, etc. via J1939 engine override commands.
3) The system commands the splitter to neutral and modulates the engine torque to allow splitter disengagement via J1939.
4) The system confirms splitter disengagement via a comparison of the ratio of **input_speed** to **output_speed** with the transmission ratio table.
5) The system implements anti-hunting routines.
6) The system modulates **engine_speed** via J1939 to synchronize the splitter for the target ratio.
7) The system senses impending synchronous via **input_speed** and **output_speed** signals.
8) The system commands the splitter toward target gear engagement.
9) The system confirms splitter engagement via a comparison of the ratio of **input_speed** to **output_speed** with the transmission ratio table.
10) The system commands the engine to reapply torque via J1939.
11) The engine resumes control of the throttle, engine brakes, cruise control, etc.

<u>Lever/Splitter Shift</u>

1) The driver display flashes the available lever position to indicate it is "OK" to shift the lever to that position.
2) When the driver desires to make the indicated lever shift, he or she pulls the lever to neutral while activating the intent-to-shift feature (TBD - either a momentary button, or a force detente in the knob or lever).
3) The system overrides the cruise control, engine brakes, throttle, etc. via J1939.
4) The system commands the splitter to neutral and modulates the engine torque to allow splitter and lever disengagement via J1939.
5) The system confirms transmission neutral via a comparison of the ratio of **input_speed** to **output_speed** with the transmission ratio table, and by the lever position sensor.
6) The system implements anti-hunt routines, commands the splitter to the target position for the new ratio, and modulates the **engine_speed** via J1939 to synchronize the transmission for the target gear ratio.

7) The driver moves the lever into the new position.
8) The system confirms the new gear engagement via a comparison of the ratio of **input_speed** to **output_speed** with the transmission ratio table.
9) The system commands the engine to reapply torque via J1939.
10) The engine resumes control of the throttle, engine brakes, cruise control, etc.

3.1 APPLICATION REQUIREMENTS AND CONSTRAINTS

3.1.1 Applications

AutoSplit includes all "On-Highway" RoadRanger-type applications. Vocations include Pickup and Delivery, LTL, TL, large and small fleets. Engine applications include all diesel engines approved for On-Highway RoadRangers that provide for SAE J1939 CAN communications.

3.1.2 Calibration Parameters

Reference Appendix A for calibration parameters.

3.2 PERFORMANCE REQUIREMENTS

3.2.1 Vehicle Startup and Shutdown

The AutoSplit system will become active (power-up) whenever **v_ignition** is asserted. Once **v_ignition** is asserted, the AutoSplit system will not be disabled (power-down) until **v_ignition** is de-asserted and **output_speed** < *min_output_spd*. No calibration or data storage is required.

Upon **v_ignition** asserted, and **output_speed** < *min_output_spd*, the system will command the splitter to the position indicated by the splitter start gear selector button/switch on the driver display. Also upon power-up, all of the driver display lights including the service lamp will light for a one second (TBD) period to facilitate a "lamp check."

Upon **v_ignition** de-asserted and **output_speed** > *min_output_spd*, the system will remain in the current gear. When **output_speed** < *min_output_spd*, the system will then power down.

3.2.2 AutoSplit Modes

Only one mode of operation is available with the AutoSplit system and is available whenever the system is active, or powered-up. This mode is explained in sections 3.2.2.1 to 4 below.

3.2.2.1 Driver Operating Procedure

To start from rest, the driver depresses the manual conventional

clutch and engages the desired lever position, as in a manual transmission. If the selected splitter starting ratio is low (direct), the starting gears can be 1, 3, 5, etc. whereas if the selected splitter starting ratio is high, the starting gears will be one of 2, 4, 6, etc. To start the vehicle, the driver releases the clutch as in a manual gearbox vehicle.

When the ECU determines that it is time for an upshift (or downshift), and the shift is a splitter-only shift (i.e., 1-2, 3-4, 4-3, etc.), the transmission automatically performs the shift just as with the AutoShift transmission.

However, a lever shift is different and is driver-initiated. For a lever upshift, the driver pulls the transmission lever to neutral while actuating the intent-to-shift switch. This switch may be "driver-active" like the momentary push-button in the concept prototype vehicle, or "driver-passive" using a force detente switch in the knob or lever (not yet developed). Activating this switch causes the system to manipulate the engine torque to achieve a torque reversal via J1939 engine override control and preselect the splitter to neutral. Alternately, the driver can just manipulate the throttle to reverse drive line torque and pull the lever to neutral. Upon sensing neutral, the system commands the splitter to its appropriate position and commands the engine (via J1939) to go to the speed for synchronous for the next gear. The driver engages the lever into the next gear position. The system detects engagement and ramps the engine torque back up to what the driver is demanding.

Note that the vehicle master starting clutch need not be held depressed during lever shifting as this would interfere with the engine control of synchronous. However, if the driver does depress the clutch at any time (clutch state reported by engine via J1939), the engine control would be returned to Engine Follower mode (no override) until the clutch is again engaged. Note that the driver could momentarily depress the clutch to move the lever to neutral without affecting the engine speed control. As soon as the system recognizes that the clutch is reengaged, Engine Speed Control can resume. If the driver "double-clutched" during a lever shift, the transmission would behave in the same manner as a manual RoadRanger transmission. Of course, no clutch action is needed on splitter-only shifts.

3.2.2.2 Driver Display Function

The driver display as pictured in Figure 3.0.1-1 has 10 lamps (LED's) that illuminate each of the 10 forward gear numbers. When the vehicle is moving and the transmission is engaged in a gear, the lamp corresponding to that gear is steadily lit (not flashing). Also when in a gear and moving, the display flashes (blinks) a lamp

other than that one already lit if the system determines a lever shift to that position is possible and allowable. Note that for a splitter-only shift the target gear would not need to flash since the system would automatically initiate that shift. When the driver initiates a lever shift and brings the shift lever to neutral and the neutral sensing routine confirms neutral, the lamp that was indicating the engaged gear turns off and the flashing lamp that was indicating an allowable shift continues flashing for that target gear, indicating that the system is now directing the engine to a speed that would result in a synchronous condition for the new gear. If the vehicle speed changes sufficiently while the transmission is in neutral for the system to change its selection for the "best" gear, the lamp corresponding to the new gear will begin flashing and the system will command the engine to go to the speed to create a synchronous condition for the new gear. When the driver engages the lever in a new position, and the system senses engagement of that new gear, and the lamp corresponding to that new position will be illuminated steadily.

The driver display also includes a push-button switch to select which splitter gear the system will engage at rest. Besides allowing the driver to start in either splitter ratio, this gives the system two reverse ratios. Two lamps indicate whether "HI" or "LO" splitter starting ratio has been selected.

3.2.2.3 Shift Scheduling

AutoSplit is unique from other automated mechanical transmissions in that its electronically-enhanced shift operations consist of both driver-initiated (lever) shifts and system-initiated, automatic (splitter) shifts. Therefore, a shift scheduling routine is used that recognizes the different types of shifts and takes different action for each. Figure 3.2.2.3-1 attempts to summarize this shift schedule. Note that AutoSplit does not permit driver-chosen skip shifting. However, the system may select a skip shift under certain circumstances (i.e., a lever downshift is initiated and the driver allows the vehicle to slow enough to choose the next lowest splitter position while in neutral).

In Figure 3.2.2.3-1, the automatic splitter-only shift points are throttle-modulated just as in AutoShift. That is, the greater the throttle opening, the higher the shift point in speed. In Figure 3.2.2.3-1, these shifts are the 1-2, 2-1, 3-4, 4-3 shifts, and so on. The allowable shift speeds for each gear are noted by the arrows. For example, for the 1-2 shift, the arrows pointing down at the upper end of the first gear "speed line" from 1500 rpm to 1800 rpm signify that 1-2 upshifts are initiated from 1500 to 1800 rpm input speed depending upon throttle (see Figure 3.2.2.3-2). Note that the arrows point down to indicate that the input speed must come down to complete the 1-2 shift.

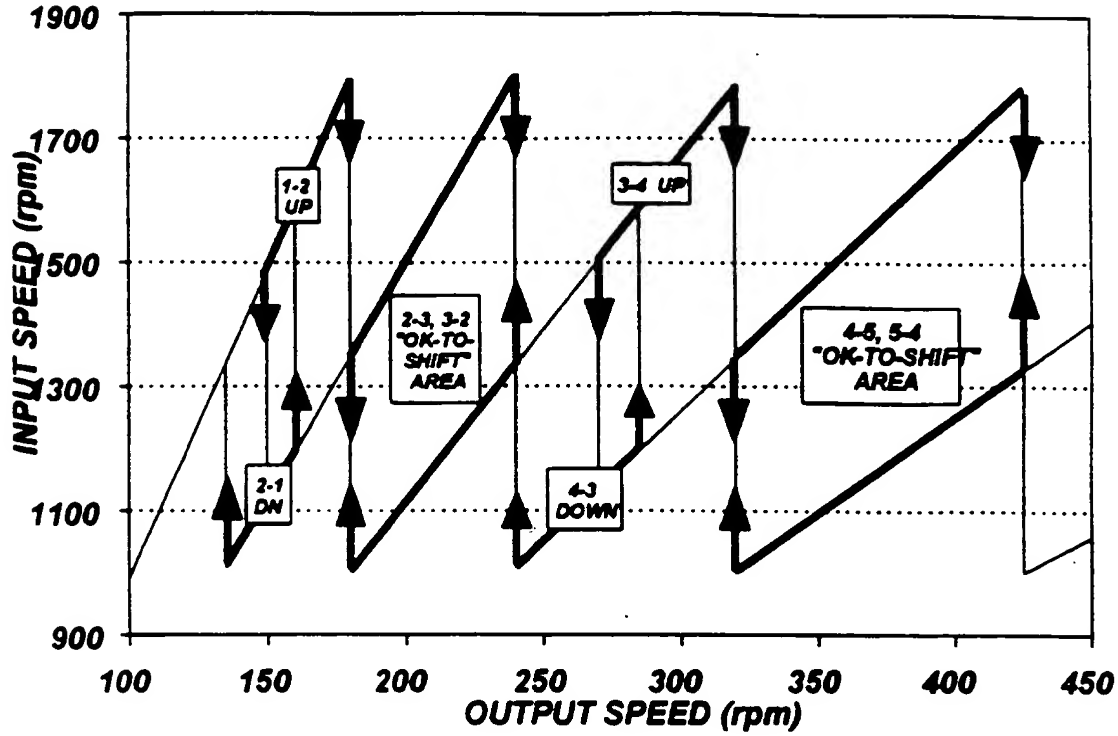

Figure 3.2.2.3-1 - AutoSplit Shift Schedule

The lever shifts on Figure 3.2.2.3-1 indicate different information than the splitter shifts do. The lever shifts are the 2-3, 3-2, 4-5, 5-4 shifts, and so on. Note that these are called "ok-to-shift areas." This means that these areas indicate allowable speeds for those lever shifts by the system. It is up to the driver to determine the input speed at which those shifts are actually initiated. Simply interpreted, if the transmission is in 2nd gear (4th gear, 6th gear, etc.), the input speed is above 1375 rpm, and neutral is sensed, the system recognizes it as a 2-3 lever shift. Once neutral is seen, the splitter is shifted to the low position and the engine is commanded to a speed that achieves synchronous for the new gear, which is 3rd. The calibrations on this figure are for an application with an 1800 rpm governed speed engine.

Figure 3.2.2.3-2 illustrates this shift logic in a different manner. Note the "notch" in the splitter upshift line above 90 percent driver demand (percent throttle). This is the software

simulating a "ride-through-detente" feature at wide-open-throttle. Each of the "curves" in Figure 3.2.2.3-2 only applies when the transmission is in the appropriate gear for that line. For example, the "lever upshifts" line only applies when the transmission is in gear 2, 4, 6, or 8. When the transmission is operating in one of these gears and the input speed is above 1375 rpm, the light on the dash display corresponding to the next higher lever position flashes indicating to the driver that it is "OK-to-shift" to the next highest gear. If the driver moves the lever to neutral (in gears 2, 4, 6, or 8) and the input speed is not above 1375, the system will synchronize (command engine to synchronous speed) for the gear that was just disengaged. Note the system has no indication of driver intentions other than **input_speed** and **output_speed**. This illustrates the importance of the driver display. A quick glance at the display by the driver instructs him or her of where the system "wants" the lever to be moved.

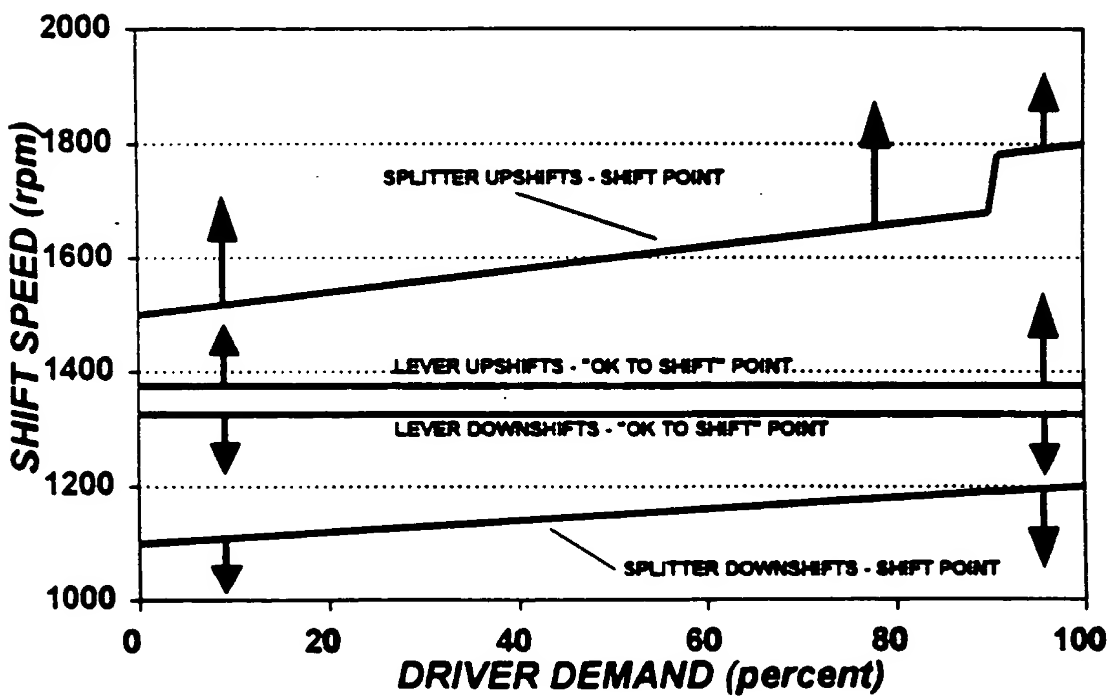

Figure 3.2.2.3-2 - AutoSplit Shift Calibrations Sample

"Driver demand" (**pct_demand_at_cur_sp**) is used in Figure 3.2.2.3-2 since it is the actual variable used by the software for shift point modulation. It is a variable that is reported by the engine via J1939. Under most conditions, it is identical to percent throttle. The exception is the condition where the vehicle cruise control is engaged and the throttle pedal is released. In this case, it is the amount of power that the cruise control is demanding to maintain its speed setting. This is beneficial in that it provides modulated shift points for splitter shifting while in cruise control. Note that AutoSplit is fully compatible with vehicle cruise control. Upshifts and downshifts can be executed (both splitter and lever) without disengaging or having to resume cruise control after the shift.

3.2.2.4 Shiftability Algorithm

"Shiftability" is an algorithm that calculates the feasibility and/or desirability of a given shift and takes action based on those calculations. Two "levels" of shiftability will be used in the AutoSplit transmission system. Both pertain specifically to splitter-only shifts. The first level is a "reactive" algorithm that will make changes once the shift has begun. The second level is "proactive" and will determine whether or not a shift is feasible or desirable before the shift is started.

3.2.2.4.1 Reactive Shiftability

The reactive shiftability algorithm monitors the **output_shaft_-acceleration** and modifies the gear engagement synchronous windows based on this acceleration. Specifically, if the vehicle deceleration (**output_shaft_deceleration**) exceeds a certain value, the synchronous window for that gear will be widened in proportion to that deceleration. This will allow earlier, farther out-of-synchronous engagement. Development of this algorithm for the R747 transmission demonstrated successful low gear splitter upshifts on grades up to 8 percent or more.

3.2.2.4.2 Proactive Shiftability

The proactive shiftability algorithm will follow the following logic rules. Note that it takes into account the reactive shiftability algorithm, as well as the presence of engine retarding devices present (i.e., an engine compression brake, engine inertia brake, etc.).

1) <u>Vehicle Deceleration Limitation Check</u>
   a) The algorithm determines if the vehicle will slow down too much during the upshift to make the shift.
      If it will, it:
   b) determines if the vehicle can make the upshift with the help of the engine brake, and/or engine inertia brake - if the vehicle/transmission is so equipped.

If it cannot, it:

c) inhibits the upshift until conditions change enough to make the shift feasible.

2) Vehicle Torque Limitation Check

a) Next, the algorithm determines if the vehicle has enough torque available in the proposed next gear to sufficiently accelerate.

If it does not, it:

b) inhibits the upshift until conditions change enough to make the shift desirable and prevent lugging or hunting.

3) Vehicle Weight Calculation

This is a variable necessary for calculations 1) and 2) above. It is also useful for many other applications. Vehicle weight (GCW) will be used in this transmission in an algorithm that will modify shift calibrations as a function of GCW to have uniformly smooth shifts across the spectrum of possible GCW values. This is explained elsewhere in this document.

The proactive shiftability algorithm is taken from the AutoShift software and modified for lever-shifted automated transmissions (a modification not yet developed as of August 1995). The algorithm is further explained in CoRD-DC Technical Report No. 94004.

3.2.2.5 Anti-Hunt Strategy

After a shift is completed, the system will start a timer and offset the next shift point to prevent hunting after splitter-only shifts based on the following conditions:

While the timer is less than *offset_time*, then the upshift point becomes *auto_up_rpm* + *up_timer_offset_rpm*. The downshift point becomes *auto_dn_rpm* - *dwn_timer_offset_rpm*.

When the timer exceeds *offset_time* and an upshift has just been completed, then the new downshift point becomes (*auto_dn_rpm* - *dwn_offset_rpm*). The downshift point reverts back to *auto_dn_rpm* when **input_speed_filtered** exceeds (*auto_dn_rpm* + *dwn_reset_rpm*).

When the timer exceeds *offset_time*, and a downshift has just been completed, then the new upshift point becomes (*auto_up_rpm* + *up_offset_rpm*). The upshift point reverts back to *auto_up_rpm* when **input_speed_filtered** speed falls below (*aut_up_rpm* - *up_reset_rpm*).

A similar strategy is used during lever shifts to move the opposite "ok-to-shift" point away during a lever shift. For example, a lever upshift is started and the transmission is in neutral. The

lever downshift point is moved away from the upshift point in the same manner as for splitter shifts above. This will help prevent the system from changing the target gear during a lever shift if the vehicle decelerates somewhat.

3.2.3 Shift Process

This, section repeats the shift sequence information of section 3.0.2 and then describes in more detail the system functions during that process. Normal AutoSplit operation consists of both driver-initiated (lever) shifts and system-initiated, automatic (splitter) shifts. The normal shift sequence for each of these shifts is described below. Every shift process is divided into three phases: Predip, Sync, and Recovery.

<u>Splitter-Only Shift</u>

1) The system detects the optimal time to shift based on load, **input_speed**, etc.

<u>>Predip phase begins here<</u>

2) The system overrides cruise control, engine brakes, throttle, etc. via J1939 commands.
3) The system commands the splitter to neutral and modulates torque to allow splitter disengagement via J1939 engine control.
4) The system confirms splitter disengagement via a comparison of the ratio of **input_speed** to **output_speed** with the transmission ratio table.

<u>>Sync phase begins here<</u>

5) The system implements anti-hunting routines.
6) The system modulates **engine_speed** via J1939 to synchronize the splitter for the target ratio.
7) The system senses impending synchronous via **input_speed** and **output_speed** signals.
8) The system commands the splitter toward target gear engagement.
9) The system confirms splitter engagement via a comparison of the ratio of **input_speed** to **output_speed** with the transmission ratio table.

<u>>Recovery phase begins here<</u>

10) The system commands the engine to reapply torque via J1939.
11) The engine resumes control of the throttle, engine brakes, cruise control, etc.

<u>Lever/Splitter Shift</u>

1) The driver display flashes the available lever position to indicate it is "OK" to shift the lever to that position.
2) When the driver desires to make the indicated lever shift, he or she pulls the lever to neutral while activating the intent-to-shift feature (TBD - either a momentary button, or a force detente in the knob or lever).

>Predip phase starts here<

3) The system overrides the cruise control, engine brakes, throttle, etc. via J1939 commands.
4) The system commands the splitter to neutral and modulates the engine torque to allow splitter and lever disengagement via J1939 engine control.
5) The system confirms transmission neutral via a comparison of the ratio of **input_speed** to **output_speed** with the transmission ratio table and the lever position sensor.

>Sync phase begins here<

6) The system implements anti-hunt routines, commands the splitter to the target position for the new ratio, and modulates the **engine_speed** via J1939 to synchronize the transmission for the target gear ratio.
7) The driver moves the lever into the new position.
8) The system confirms the new gear engagement via a comparison of the ratio of **input_speed** to **output_speed** with the transmission ratio table.

>Recovery phase begins here<

9) The system commands the engine to reapply torque via J1939.
10) The engine resumes control of the throttle, engine brakes, cruise control, etc.

3.2.3.1 Predip Phase

Upon entering the Predip phase of the shift, the AutoSplit system will first temporarily disable the engine brakes then override throttle and cruise control, by entering the Engine Torque Control mode of J1939. For splitter-only shifts this occurs as soon as the system determines it is time for an automatic splitter shift. For lever shifts this occurs when the intent-to-shift switch is activated (if it is activated).

The system will then command the splitter to change state and enter the Engine Torque Control mode and perform torque modulation in accordance with Figure 3.2.3.1-1. Note that torque is "ramped" down first to the torque needed for zero drive line torque, held there momentarily, then ramped down to zero. Then, if neutral is still not seen, the torque "pulses" begin - starting with a "zero drive line torque" pulse. The gross engine torque (**actual_engine_pct_trq**) needed to create zero drive line torque is a dynamic variable continuously calculated by the system, and is a function of gross engine torque and engine friction (both reported by the engine via J1939), accessory torque (continuously calculated by the system), and engine acceleration. Note that if the gross engine torque is less that 5 percent, the Predip phase will commence directly with the "zero drive line torque" pulse as shown in Figure 3.2.3.1-1 (i.e., coasting downshifts).

The Predip phase torque "ramp-down" rate will be adjusted as a

function of gross combination weight (GCW) using the GCW value determined in the shiftability calculations. This will provide smooth operation across the range of GCW's. A default GCW representative of the average of the possible GCWs (50,000 lbs.) will be used upon power-up and until a sufficient approximation of GCW can be calculated (after a few upshifts).

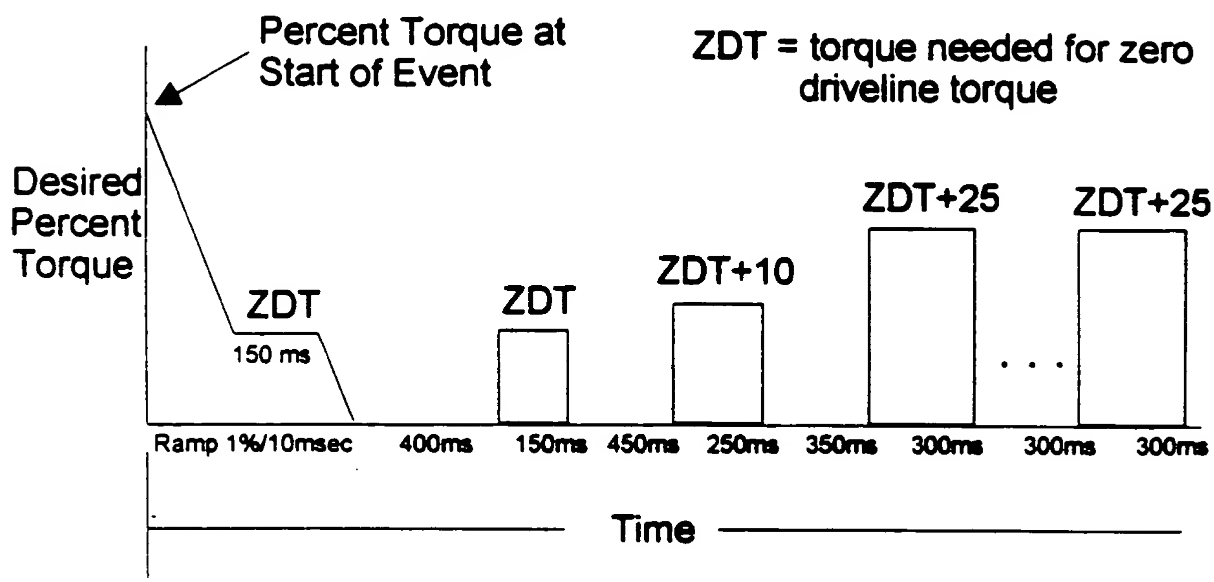

Figure 3.2.3.1-1 - Predip Phase Torque Control

Transmission disengagement will be confirmed when the <u>determine gear</u> software function indicates that the current gear ratio has disengaged using the **input_speed** and **output_speed** variables. For <u>splitter-only shifts</u>, this disengagement is due to the splitter moving to neutral. For <u>lever shifts</u>, it is either the splitter, or the lever, or both, that causes the system to sense disengagement. If the intent-to-shift switch is activated, the splitter almost always comes to neutral before the lever is brought to neutral. However, if the driver pulls the lever to neutral without activating the intent-to-shift switch, the Predip phase

doesn't start until neutral is sensed, at which point the system goes immediately to the Sync phase.

The Predip phase is complete as soon as the determine_gear software function detects transmission neutral. Note that during lever shifts, the shift lever may be moved to neutral during either the Predip or the Sync phase.

3.2.3.2 Sync Phase

After confirming transmission disengagement, the shift will enter the Sync phase of the shift. The AutoSplit system will command Engine Speed Control mode via J1939 and request the engine to go to the calculated synchronous speed of the target gear based on current **output_speed**. Also upon entering the Sync phase, for lever shifts the splitter is commanded to engage the new ratio as soon as lever neutral is sensed. For splitter-only shifts, the splitter is commanded to engage the new ratio when synchronous for the new gear is sensed. Note that reengaging the splitter in the Sync phase as soon as lever neutral is seen prevents the driver from engaging the wrong new lever position, since the front box "grinding" will occur.

Note that when the engine is commanded to synchronous speed for the new gear, it is commanded to a speed that is a fixed amount "away" from synchronous for that gear. Note that if nearly exact synchronous speed was commanded, the determine_gear software function would "think" that the transmission is in a gear. Therefore, the engine is commanded to a speed either "above" or "below" (depending upon shift conditions) synchronous that would achieve 35 rpm of speed difference across the intended engaging dog clutch and gear. Then, the determine_gear software function would be "looking" for a synchronous speed between + and - 30 rpm across the engaging dog clutch to sense engagement.

The Sync phase is complete when the system confirms engagement of the new gear using the determine_gear software function. Engagement will be confirmed when (gear ratio ± *gr_error*) indicates the engaged gear ratio for a time period of greater than *gear_in_time_lever* (or *gear_in_time_auto* for splitter shifts). If engagement is not confirmed by *sync_time*, the system will command opposite splitter state and repeat the synchronizing process for a maximum of *split_attempts* before setting an "Unable to Select Splitter Direct/Indirect" fault and entering a degraded mode of operation.

3.2.3.3 Recovery Phase

Once engagement of the new gear is confirmed, the engine control is gradually returned to the engine/driver in a controlled manner. If **pct_demand_at_cur_sp** (which is an input reported by the engine via

J1939 proportional to throttle, cruise control demand, etc.) is greater than 5 percent, the torque limit is set to that needed for zero drive line torque, then ramped up from there at 1 percent per 10 msec. If **pct_demand_at_cur_sp** is less that 5 percent, the Engine Speed Control mode is invoked and the desired speed is set to the current engine speed, then ramped down in speed from there. This speed ramping on downshifts prevents the sharp negative drive line pulse due to engine motoring.

The Recovery phase torque ramp-up rate will be adjusted as a function of vehicle weight (GCW) using the GCW value determined in the shiftability calculations. This will provide smooth operation across the range of vehicle weights.

After recovery is complete, J1939 engine override control is returned to Engine Follower mode (no override).

3.2.3.5 Speed Calculations

Input_speed and **output_speed** calculations are used continuously throughout the AutoSplit algorithms. **Input_speed** is derived from the **engine_speed** value as reported from the engine via J1939. **Output_speed** is derived from the transmission-mounted output speed sensor and will be calculated on a 10ms maximum time interval. The most time critical calculations occur during the synchronizing process. A single pole filter is required for the **output_speed** calculation. Further filtering of these signals is done as necessary for specific software functions that require heavier filtering. Fault detection and handling is covered in sections 8.3 Fault Detection and Fault Tolerance.

3.2.4 Special Cases

Any scenarios that are not a fault condition but require special action, are discussed in the following sections.

3.2.4.1 Tire Skid

Whenever **output_shaft_acceleration** is less than (-)*skid_limit*, then:

1. Save the last valid **output_speed** prior to the skid condition.
2. If the determine_gear software function indicates a gear is engaged, stay in that gear.
3. If the function indicates neutral, stay in neutral.

Continue with steps 1 - three until (**output_speed**/*skid_timer_const*) time has expired, or **output_shaft_acceleration** is greater than (*skid_limit*/2), or **output_speed** ≤ *min_output_spd* and stable for five seconds.

3.2.4.2 Unexpected Neutral

Since a driver is an integral "input" to the control system, situations may arise (i.e., after a lever shift, etc.) in which the lever may be reengaged but the transmission is neutralized due to the splitter grinding, range still on the block, etc. This situation was encountered occasionally during development and demonstrations.

To ensure reengagement, every two seconds while in the Sync mode, the engine is commanded to momentarily pass through synchronous speed and then back to the normal 35 rpm below synchronous. Confirmation of gear engagement is suppressed during this time. This will "unblock" the range and/or the splitter.

3.2.4.3 Wrong Lever Position Engagement

If the driver attempts to engage a different lever position than the system is synchronizing for (and the display is flashing), usually the transmission will just grind and block the lever from engaging the gear. However, if the driver depresses the clutch far enough to engage the clutch brake, the lever generally can be engaged in the wrong position. To prevent the system from going into the Predip phase indefinitely, the system will check for this condition (current gear not equal to destination gear) every time it confirms engagement of a new gear.

3.2.4.4 Long Periods of Neutral During Vehicle Movement

If the driver leaves the lever in neutral for a long period of time (longer than the normal 1 to 2 seconds), the shift process will remain in the Sync mode until gear engagement is confirmed. During this time, the system will continue to command the engine to the synchronous speed minus 35 rpm indefinitely if the driver has the throttle depressed. If the throttle is not depressed, the system will switch to Engine Follower mode (no override) after 3 seconds in the Sync mode. The system will resume active engine control - commanding the engine to synchronous speed minus 35 rpm for the target gear flashing on the display.

4 COST, RELIABILITY AND DUTY CYCLE

Refer to the AutoSplit Product Design Specification.

5 ENVIRONMENT

Refer to the AutoSplit Product Design Specification.

6 AutoSplit INTERFACE REQUIREMENTS

Refer to the AutoSplit Product Design Specification.

7 MANUFACTURING, PURCHASING, AND QUALITY

7.1 Final Assembly and Calibration

7.1.1 Final Subassembly Programming

AutoSplit calibration and configuration parameters will be programmed into the ECU at the time of the final subsystem assemblies. A default set of configuration parameters particular to the vehicle and engine type will be programmed into the ECU at the end of the ECU final assembly. These parameters consist of shift point selection parameters and vehicle configuration parameters.

Transmission specific configuration parameters will be programmed into the ECU at the end of transmission final assembly. These parameters will consist of front box and back box gear ratios, back box range and splitter positions, and speed sensor requirements (number of teeth per revolution). Transmission specific calibration functions will be performed and the resulting calibration parameters will be loaded into the ECU prior to the end-of-line transmission test.

7.1.2 AutoSplit System Final Assembly Programming

Final calibration and configuration parameters particular to the vehicle and engine type will be programmed at the OEM end-of-line checkout once vehicle specifics are known. These parameters will be programmed according to SAE J2214 recommended practice titled "OEM/Vendor Interface Specification for Vehicle Electronic Programming Stations.

7.2 Final Test and Certification

Refer to the AutoSplit Product Design Specification.

8 SERVICE

8.1 Service Level

Refer to the AutoSplit Product Design Specification.

8.2 Serviceability and Service Time

8.2.1 On-Board Diagnostics

On-board diagnostics will be performed on a continuous basis during operation. The diagnostic routines will check all sensors, and solenoids. See section 8.3, Fault Detection and Fault Tolerance for additional information.

8.2.2 Service Time
Refer to the AutoSplit Product Design Specification.

8.2.3 Diagnostic Tests
None.

8.3 Fault Detection and Fault Tolerance
Faults are set and specific action is taken to keep the vehicle operational, taking into account the ability to continue operation without further damaging the transmission or inducing additional mission disabling conditions. Degraded mode response to the faults indicated below are found within the fault description below. All active faults that indicate a component failure turn on solid or flash the "Service Transmission Lamp." If a fault occurs during a shift, unique action required to complete the shift is specified below as well.

8.3.1 System Battery Voltage Fault
This fault is set whenever battery voltage is detected to be high (Vbatt > 18v), weak (9 < Vbatt < 11), or low (Vbatt < 9). The system goes to "hold in gear with no engine override" until the Vbatt is returned to normal. The transmission may be driven as a manual 5-speed.

8.3.2 Ignition Voltage Fault
This fault is set whenever ignition voltage is detected high (Vbatt > 18v). Result same as 8.3.1.

8.3.3 ECU Fault
This fault is set whenever the system ECU calculates an incorrect RAM, ROM, or EEPROM checksum. The system holds in the present gear with no engine override until the problem is corrected (i.e., after a power-down and power-up). The transmission may be driven as a manual 5-speed.

8.3.4 Output Shaft Speed Sensor Fault
This fault is set whenever the system detects an open or short in the speed sensor circuit. The system holds in the present gear with no engine override until the problem is corrected. The transmission may be driven as a manual 5-speed.

8.3.5 Unable to Select Splitter Indirect Fault
This fault is set whenever the splitter has failed to complete to indirect after *split_attempts* splitter attempts. The system holds in the present gear with no engine override until the problem is corrected. The transmission may be driven as a manual 5-speed.

8.3.6 Unable to Select Splitter Direct Fault

This fault is set whenever the splitter has failed to complete to direct after *split_attempts* splitter attempts. The system holds in the present gear with no engine override until the problem is corrected. The transmission may be driven as a manual 5-speed.

8.3.7 Ignition Switch Turned Off Fault

This fault is set whenever ignition voltage is not detected during vehicle movement. The system holds in the present gear with no engine override until the problem is corrected. The transmission may be driven as a manual 5-speed.

APPENDIX A - CALIBRATION PARAMETERS

Below is a draft list of calibration and/or EEPROM parameters required for AutoSplit control. An effort should be made to reduce or "hard code" as many as practical.

This section is incomplete.